STATE OF ILLINOIS
DEPARTMENT OF REGISTRATION AND EDUCATION
A. M. SHELTON, *Director*

DIVISION OF THE
STATE GEOLOGICAL SURVEY
M. M. LEIGHTON, *Chief*

REPORT OF INVESTIGATIONS—NO. 6

PROPER TESTING FOR OIL STRUCTURES IN ILLINOIS AND SOME AREAS DESERVING SUCH TESTING

BY
GAIL F. MOULTON

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By Gail F. Moulton

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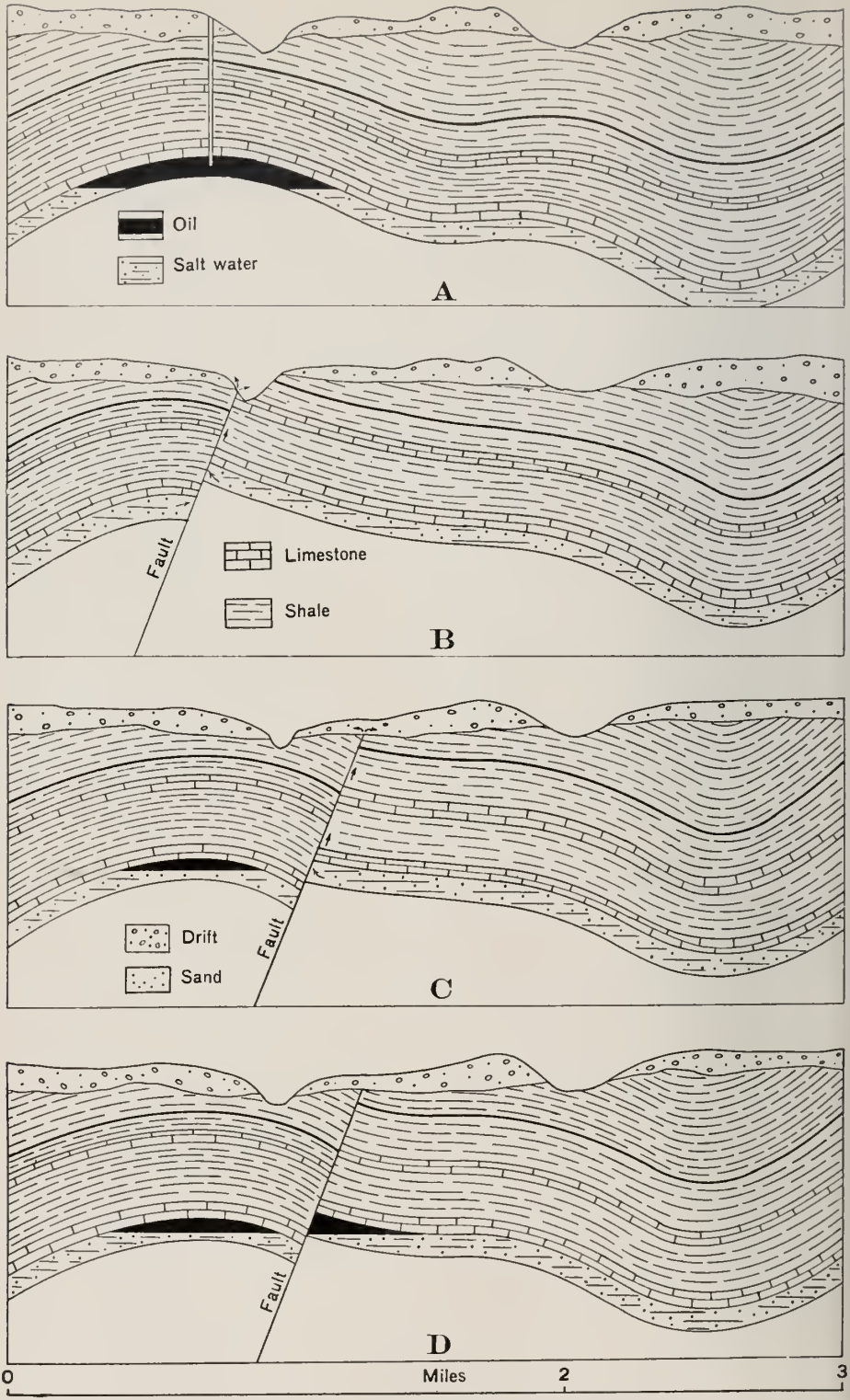

FIG. 1. Diagrammatic cross-sections showing effect of geologic structure on oil accumulation. In B the fault plane is supposed to afford a channel by which the oil has escaped, whereas in C and D the structure forms an effective trap.

PROPER TESTING FOR OIL STRUCTURES

Introduction

Studies by the oil and gas section of the State Geological Survey reveal a number of localities in Illinois which appear to have structures worth testing for oil. Few of these are definitely outlined, but many good locations are likely to be found by drilling a few wells to a shallow key horizon. It is the purpose of this report to outline the most satisfactory method of exploring for oil in Illinois and to call attention to some of the areas which are worthy of testing. Other areas will be described in later reports.

Test Drilling for Structure

Test drilling as considered here, includes all drill holes, both diamond and churn drilled, which are carried down to some shallow bed that can be recognized easily over considerable areas. Generally limestones and coal beds have been used as key beds, because they are easily recognized by the driller and are usually logged. Data from a number of such tests can be used to determine the amount and direction of dip or slope of the beds of underlying rocks. Because in most parts of the State the rocks at considerable depth have a structure similar to that of the rocks near the surface, especially in local features, the determination of the structure of shallow key beds helps to determine the structure of deeper rocks which might contain oil or gas.

The Relation of Oil Accumulation to Geologic Structures

The oil pools which have been found in Illinois occur chiefly along the high parts of domes and anticlines. A similar relation between rock structure and oil accumulation has been observed in many other fields. The general relations are indicated in figure 1, in which A illustrates the typical case of an unfaulted area; B shows a fault permitting the escape of oil and gas; C and D show faults which assist in causing oil accumulation. Lately, such fault structures causing accumulation are known as the "Mexia" (Me-Hé-a) type.

Knowledge of the relation of oil accumulation to structural features has resulted in a program of locating oil tests on anticlines and domes. Considerable success in finding new oil pools has followed. In view of the fact that the risks of oil prospecting are considerably reduced by drilling on promising structures, favorable structural features should be found before drilling for oil and gas.

Determination of Structure

FIELD CONDITIONS IN ILLINOIS

In many regions outside Illinois, the rock strata outcrop and the geologic structure can be determined by the correlation of key beds from surface observations. In Illinois, however, the thick cover of glacial deposits generally conceals the consolidated rocks so that in most parts of the State it is necessary to depend on subsurface data from wells for determining the structure. Figure 1 shows how a cover of glacial drift obscures the structure of the bed rock below, and also shows the lack of significant relation between topography and structure of the underlying rocks in a glaciated region. For example, in figure 1 B there is a considerable hill which overlies a structural depression or syncline in the right side of the diagram. A valley is also shown over part of an anticline in figure 1 A. This situation is typical for most of Illinois, and so the "lay" of the land is not dependable in determining the oil possibilities.

THE USE OF KEY BEDS AND STRUCTURE TESTS

In figure 1, a coal bed is shown which would be suitable for use as a key horizon in structural determinations. Test wells would give the depth of this bed at different points. Then, by subtracting the depth of the bed from the altitude of the top of each well, altitudes for various points on the surface of the key bed could be obtained to determine the structure. Obviously, accurate determinations of both the depth of the bed and the elevation of the well are required for accurate results. Careful and complete records of the wells are also essential for accurate identification of the key beds used.

GEOLOGICAL DATA ALREADY AVAILABLE

Thousands of coal tests and oil wells have been drilled in Illinois, and as a result of the efforts of the Illinois State Geological Survey, numerous records have been collected and studied. Structure maps for various parts of the State that have been prepared from these records have been published in connection with quadrangle studies, and coal and oil investigations. An oil and gas map of the State[1] showing the known structures, both producing and nonproducing, has been compiled from the more detailed maps. In a few cases the domes indicated were definitely outlined by the information available from shallow tests. Some such structures have since produced oil or gas.

More commonly the data have been sufficient to indicate only the presence of an irregularity in dip which might be due to a real doming, but for

[1] Oil and gas field map of Illinois; by U. S. Geological Survey and Illinois State Geological Survey in cooperation, 1921.

which neither the form nor the highest point are known. In many such cases a few test wells to a shallow depth would give the data necessary for a definite determination of structural conditions. Areas of this kind have been described near Decatur and Taylorville.[2]

The Expense of Haphazard Drilling

The drilling of deep tests without first attempting to determine the structure is both expensive and unjustified. A consideration of the relative costs of test drilling and drilling to depth for oil emphasizes the saving to be made by drilling test wells first. Recent drilling near Decatur seems to be rather typical of the development that is carried out generally in the State. Here the value of shallow tests was ignored, and several deep tests were drilled. The estimated cost relations are indicated in the accompanying table.

Table 1. *Comparative cost of development methods.*

Plan used at Decatur	Cost	Good test drilling program	Cost
5 deep tests (2000 feet) at average of $7500 each	$37,500	10 tests to coal (400 feet) at $1000 each	$10,000
		2 deep tests (2000 feet) at $7500 each	15,000
Total	$37,500	Total	$25,000

According to these figures, test drilling would have resulted in the saving of $12,500 or 33 per cent of the approximate cost of the drilling at Decatur. In addition there are other advantages in the test drilling plan. At the present time the deep wells drilled at Decatur have not shown whether a closed dome of commercial promise exists there or not. In fact, the best location may be untested. A series of shallow tests followed by drilling of two deep tests would have determined the size, form and location of the structural features in the area, and, if significant, would have insured testing of the most favorable parts of the area. Further, a few indiscriminate deep holes may give an area a bad reputation, whereas methodical, inexpensive tests to key horizons may later show it to be a possible producing area if drilled in the proper location. The drilling of shallow structure tests before putting down deep tests is effective insurance against premature and undeserved bad reputations.

The situation at Decatur, which is neither better nor worse than many others in the State, has been used as an illustration in the hope that Illinois prospectors will do at least a small amount of preliminary exploration in

[2] Collingwood, D. M., Further considerations of prospects for oil in the Decatur area: Ill. State Geol. Survey, Rept. of Investigations No. 1, 1924.

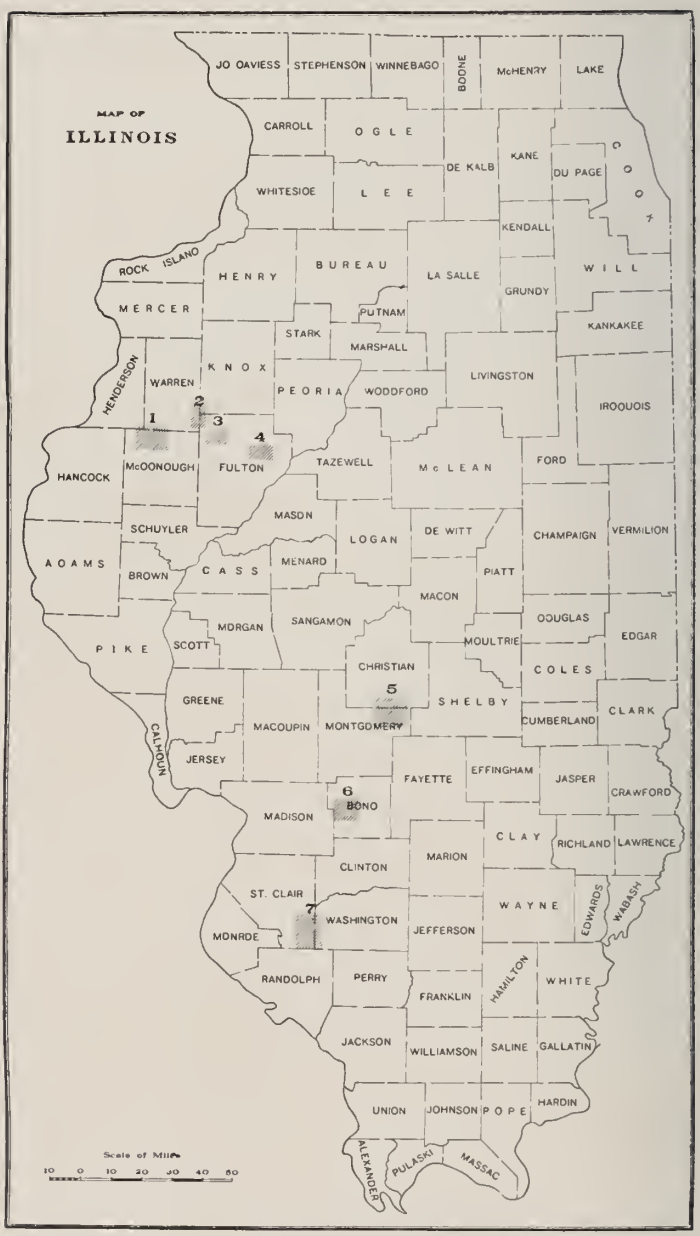

FIG. 2. Index map showing by shading the location of areas described in the report.

1. Good Hope area.
2. Avon area.
3. Babylon area.
4. Canton area.
5. Nokomis-Ohlman area.
6. Stubblefield area.
7. Darmstadt area.

advance of deep drilling. In many localities 2 or 3 tests to a depth of approximately 200 feet would give the information needed. Test drilling of this kind should have a definite and permanent place in any development program in a wildcat territory of the Illinois type.

Survey Cooperation in Test Drilling

The Illinois State Geological Survey is glad to cooperate with interested parties by giving available logs of wells, drilling depths, and other helpful information. The Survey also extends its best service to operators and drillers in identifying the various rock formations encountered and in sampling the waters of the various horizons. Well record books and convenient equipment for saving well cuttings will gladly be sent without charge upon request. Conferences in regard to applying the above structure-testing plan are invited.

SOME AREAS DESERVING OIL STRUCTURE TESTING

Introduction

Certain areas which should be prospected for oil by the method of test drilling for structure, are described in the following pages. Most of these have been described in previous publications, but they are brought to the attention of drillers in the hope that some of them will be tested during the coming year and found to be of commercial promise. The areas in western, central and southern Illinois recommended for prospecting are located on the index map (fig. 2).

Favorable Areas in Western Illinois

A recent investigation[3] showed that testing on known structures in a large area in western Illinois resulted in finding important accumulations of oil or gas on fifty per cent of the structures. At the present time, several structures of similar character are known to be untested.

FULTON COUNTY

Two areas in Fulton County which seem to merit further testing have been indicated on the Oil and Gas Map as the Canton and Babylon anticlines and have previously been described in a bulletin of the Geological Survey.[4] The accompanying sketch maps (figs. 3 and 4) are taken from the report on the area and show the form and locations of the anticlines in a

[3] Collingwood, D. M., Oil testing in Illinois: Ill. Acad. of Science meeting of 1923.

[4] Savage, T. E., Geology and mineral resources of the Avon and Canton quadrangles: Ill. State Geol. Survey Bull. 38, pp. 209-271, 1922.

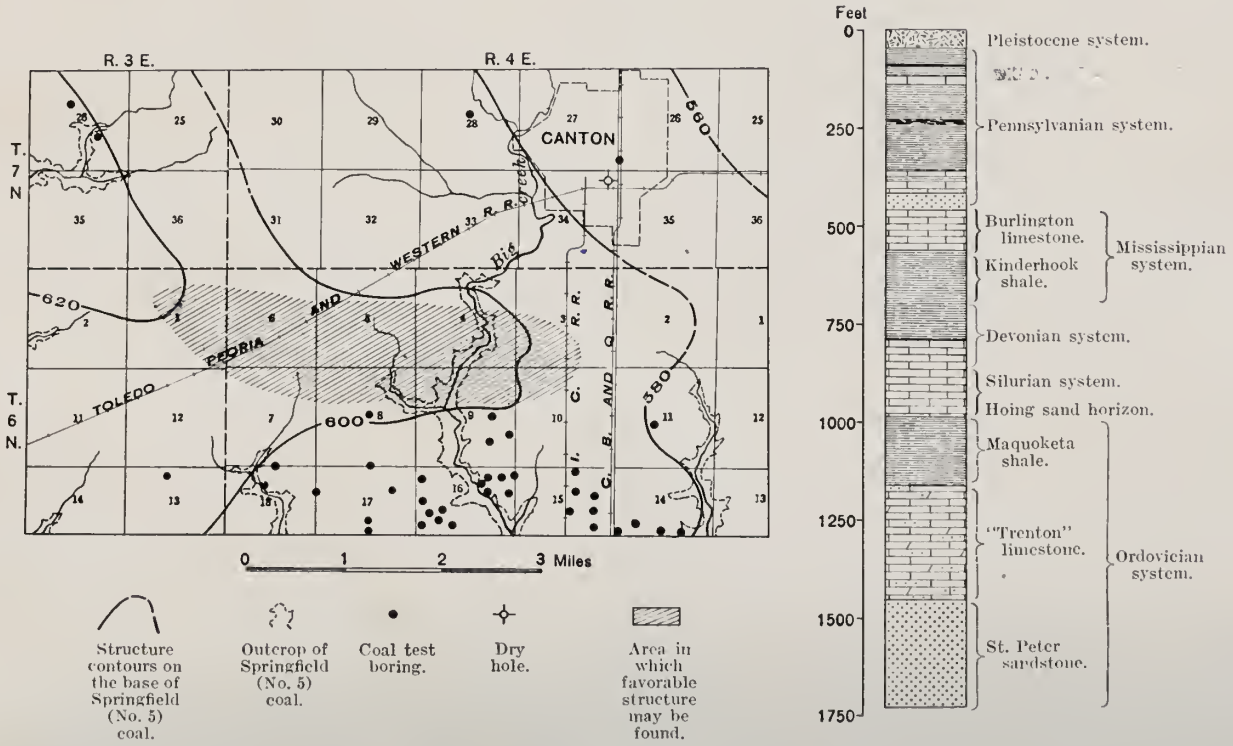

FIG. 3. Structure map and generalized columnar section of area near Canton in Fulton County.

general way, because the tests to coals have not been distributed widely enough to give uniformly detailed structural information.[5]

THE CANTON ANTICLINE

The shaded area southwest of Canton includes the highest part of a plunging anticline, which has been mapped by using data on the elevation of a persistent coal bed reported in coal tests, and found in outcrop along some of the streams. The coal tests and outcrops are located on figure 3. Further testing on the north and west sides of the shaded area are needed to outline the structure more definitely.

The structure tests should be drilled to a depth of about 100 feet to reach the base of the Springfield coal. The outcrops of coal along the streams, as shown, give information on the structure in the eastern part of the area, so the structure needs to be determined only on the north and west sides. Probably three or four tests drilled north and west of the Toledo, Peoria and Western Railroad around the border of the shaded area will show whether this is a closed structure.

Three possible oil horizons should be tested in this area if the structure is found to be favorable. These are the Devonian lime at about 800 feet, the Hoing sand horizon at a depth of about 900 feet, and the Trenton lime at 1100 to 1400 feet. The top of the St. Peter sandstone will probably be reached at about 1400 feet. (See columnar section, fig. 3.) Oil tests should not be drilled below this horizon.

THE BABYLON ANTICLINE

The Babylon anticline (fig. 4) has also been determined from the combined use of drill records and data from outcrops. The shaded area includes the part of the fold in which doming seems most likely to be found.

Tests for structure should be drilled on the north and northwest sides of the shaded area to determine whether or not this represents a closed structure. The key horizon nearest the surface is the Colchester coal. Tests to this key bed would be about 50 feet deep over most of the area, but care should be taken to avoid locating a test where the coal has been removed by erosion. Probably three tests would give the information necessary to determine the presence of a dome.

If favorable structure is found in this locality, a deep test should be drilled through three possible oil horizons. These are the Devonian lime at about 700 feet, the Hoing sand horizon at about 800 feet and the Trenton lime from 1000 to 1300 feet. The top of the St. Peter should be reached at about 1300 feet and marks the limit of known oil possibilities. (See columnar section, figure 4.)

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[5] Topographic maps of these areas are published and may be obtained by writing the Chief, Illinois Geological Survey, Urbana, for maps of Canton and Avon quadrangles. Index maps showing the areas which have been surveyed are also available upon request.

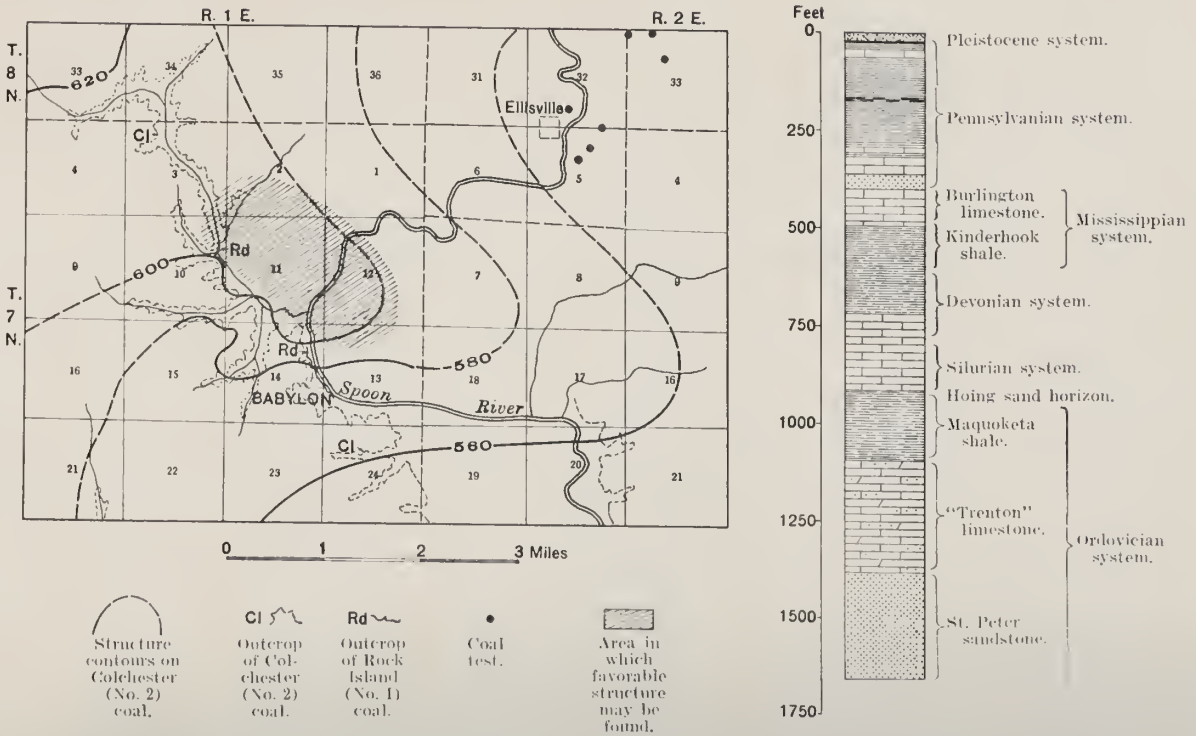

FIG. 4. Structure map and generalized columnar section of area near Babylon in Fulton County.

FULTON AND WARREN COUNTIES

THE AVON AREA

The Avon area, which includes parts of Fulton and Warren counties, appears to have structural conditions favorable for the accumulation of oil or gas. The structure in this area has also been mapped by use of data

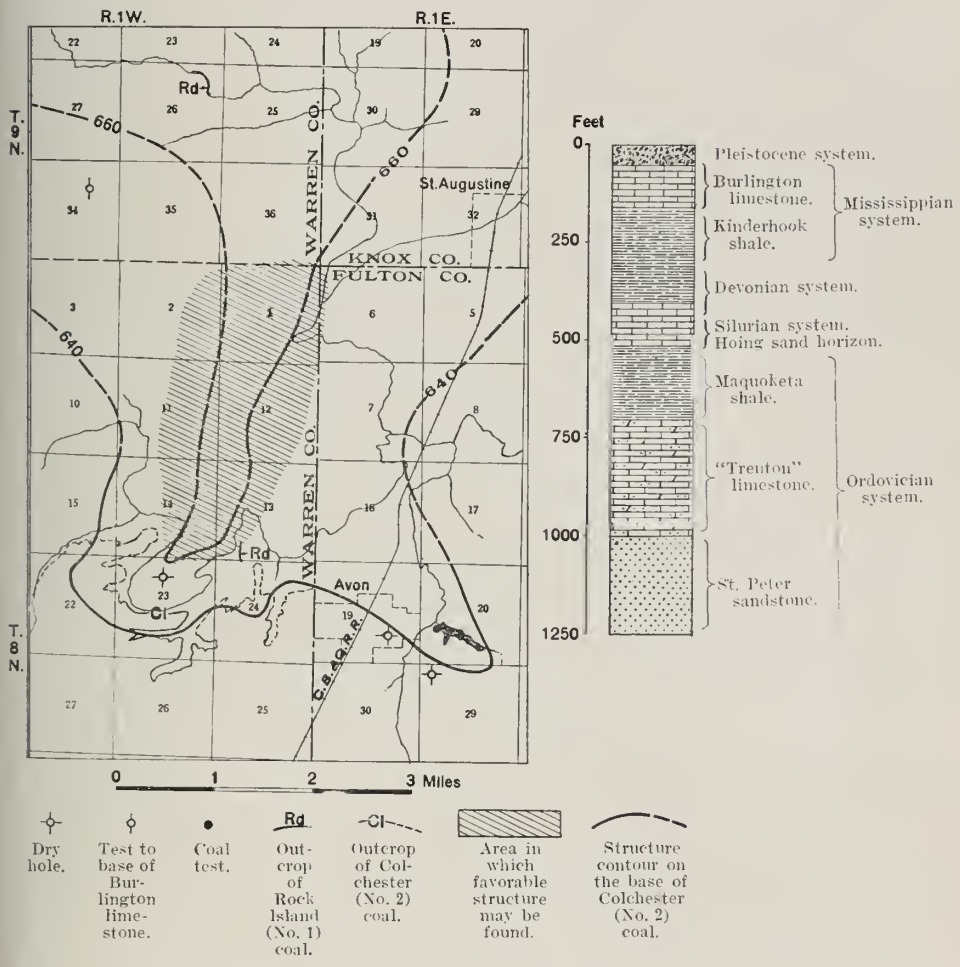

FIG. 5. Structure map and generalized columnar section of Avon area in Fulton, Knox, and Warren counties.

from drill holes and outcrops of the Colchester coal.[6] The deep tests shown in the sketch map (fig. 5) indicate that this fold is more pronounced in the deeper beds than in the coal.

[6] Savage, T. E., Geology and mineral resources of the Avon and Canton quadrangles: Ill. State Geol. Survey Bull. 38, pp. 209-271, 1922.

In order to complete the structural determinations, structure tests should be drilled across the north and in the central part of the shaded area. Such tests would determine the presence of possible north dip and the location of the highest part of the structure. Four or five test wells, if properly located, would give the information needed.

The base of the Burlington limestone is the best key available in this area. It should be found at a depth ranging from 200 to 300 feet according to local conditions. This drilling should be inexpensive because little casing will be required and the lower formations should not cave or cause other difficulties.

In case favorable structural features are found, the beds above the St. Peter sandstone should be tested for oil and gas. The possible oil horizons which would be tested by such drilling are the Devonian limestone at a depth of about 400 feet, the Hoing sand horizon at a depth of about 500 feet, and the Trenton lime at about 700 feet. A test to about 1050 feet would be deep enough to constitute a thorough test on the higher parts of the fold. (See columnar section, fig. 5.)

HENDERSON, MCDONOUGH, AND WARREN COUNTIES

SCIOTA-GOOD HOPE AREA

Near Sciota in northwestern McDonough County, is an area which seems to have structural conditions favorable for oil accumulation. Figure 6 is taken from a detailed report of the State Geological Survey on this general area.[7]

The published geologic map of the LaHarpe-Good Hope quadrangles indicates the presence of a broad general arch with a north-south trend extending from the vicinity of Stronghurst in sec. 25, T. 9 N., R. 5 W., southeast and south to the Colmar-Plymouth fields in southwestern McDonough County. The structure of the area has been determined from data on the elevation of the base of the Burlington limestone. Data examined in connection with the present report indicate that the shaded area shown on the map is probably bounded on the north and south by small synclines.

In the Sciota-Good Hope locality, it would probably be advisable to drill the first test near the center of the shaded area, and to continue testing both north and south. If this plan is followed, the first test might show whether marked doming has taken place in the vicinity. Tests along the north and south borders of the shaded area would give information required for determining the size and shape of any dome which might be found. Probably six tests are required for determining the structure in this area.

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[7] Savage, T. E., and Nebel, M. L., Geology and mineral resources of the LaHarpe-Good Hope quadrangles: Ill. State Geol. Survey Bull. 43, 1921. Topographic maps are available.

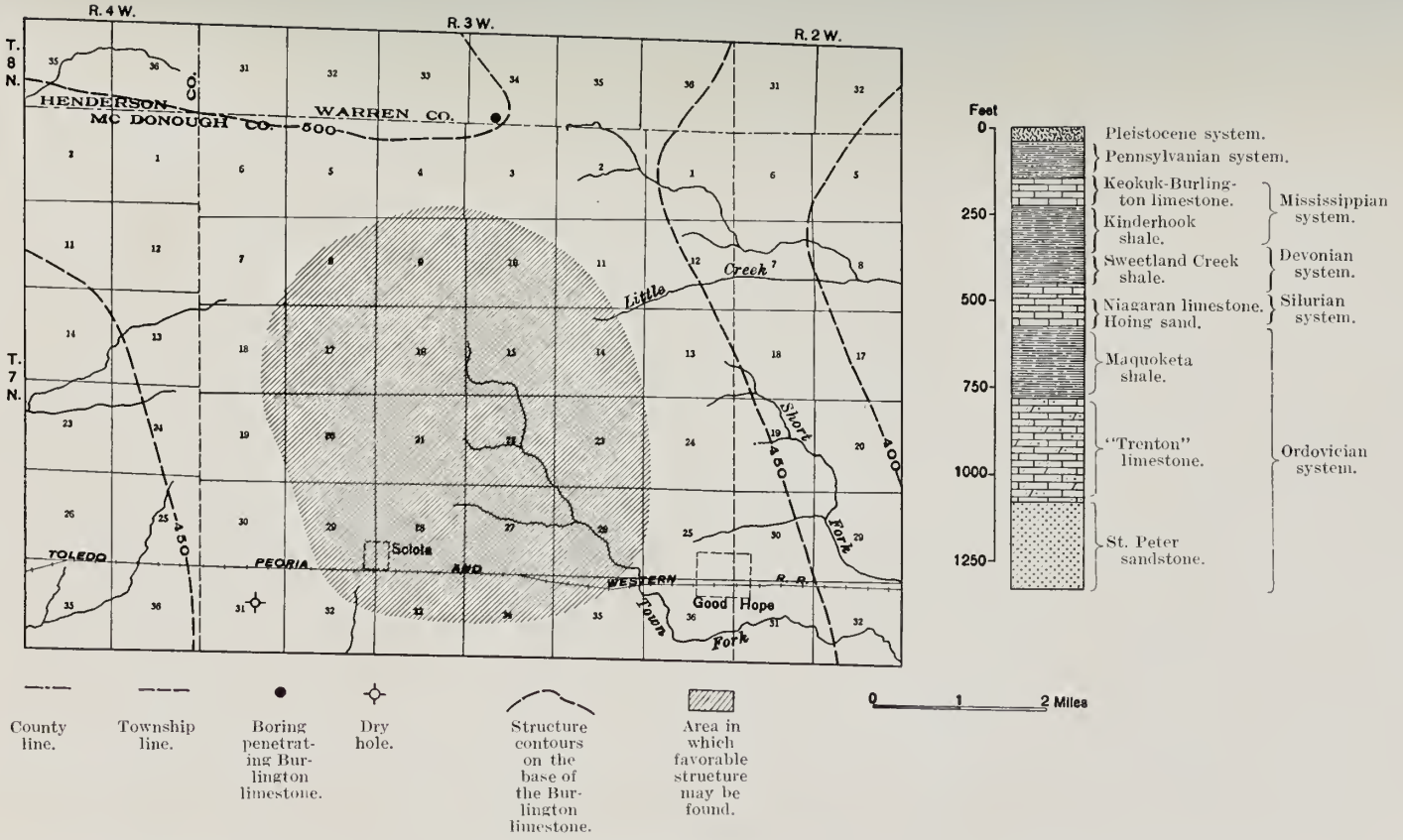

FIG. 6. Structure map and generalized columnar section of area near Good Hope in McDonough County.

The base of the Burlington limestone is the best key horizon available here. Over most of the shaded area it should be found at depths varying from 200 to 300 feet. The cost of tests should be low because of the favorable drilling conditions.

Three possible oil producing horizons should be tested in the area if favorable structural conditions are found. These are the Devonian lime at about 500 feet, the Hoing sand horizon at about 600 feet, and the Trenton lime at about 800 feet. A well drilled to a depth of 1100 feet would test the possibilities of all these horizons. (See columnar section, fig. 6.)

Favorable Areas in Central Illinois

The general results of testing domes and anticlines in central Illinois have been satisfactory.[8] Nearly half of the domes tested have yielded either oil or gas. In this area, too, several promising structures are known to have been inadequately tested. Two of these are described in this report.

BOND COUNTY

STUBBLEFIELD ANTICLINE

The Stubblefield anticline south of Greenville has produced gas for several years. More recently the Ohio Oil Company and the Bond County Gas Company have drilled a few small gas wells on the Ayers anticline north of Greenville. Both of these anticlines have been shown on the Oil and Gas Map.

A recent consideration of the well data from Bond County resulted in the structural interpretation shown in figure 7. Abrupt changes in the elevation of certain beds as determined from well logs lead to the conclusion that a fault crosses the Stubblefield anticline in the position shown. The vertical displacement of this fault is approximately 40 feet. As the west side went down relative to the east, a closed structure similar to a dome is produced by the intersection of this fault and the Stubblefield anticline. This type of structure, which was shown in figure 1, has produced large quantities of oil in Texas and smaller amounts in many other states.

Test drilling to determine the location of the crest of the anticline and the exact trend of the fault should precede any deep drilling for oil. A series of tests scattered along the highest part of the fold should accomplish both purposes. Probably 5 tests properly located would provide the desired information.

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[8] Collingwood, D. M., Oil testing in Illinois: Ill. Acad. of Science meeting of 1923.

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Devonian system.

Silurian system.

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Supplement to Report of Investigations No. 6

REVISED DATA ON STUBBLEFIELD ANTICLINE, BOND COUNTY, ILLINOIS

Instrumental levels of wells which were determined since the publication of Report of Investigations No. 6 necessitate revision of the structure map, figure 7, page 17. The new data, which are tabulated below, indicate that the fault shown probably does not exist and no closed structures are indicated. Deep testing for oil is not recommended unless shallow testing to coal No. 6 indicates the presence of closed domes.

Location Sec.	T.-N.	R.-W.	Company and well	Surface elevation (Feet)	Coal No. 6 Depth (Feet)	Elevation (Feet)
SE. SW. 4	5	4	Producers Oil Co. Phillipson No. 1	500	390	110
SW. NE. 4	5	4	Producers Oil Co. Plog No. 1	519	396	123
NE. NW. 9	5	4	Producers Oil Co. Sam Brown No. 1	499	390	109
NE. NW. 9	5	4	Producers Oil Co. Sam Brown No. 2	497	370	127
SE. SE. 10	5	4	Donk Bros. Coal & Coke	481	383	98
SE. SE. 11	5	4	Donk Bros. Coal & Coke	483	387	96
NW. NW. 15	5	4	Producers Oil Co. E. S. Delaplane	512	380	132
SW. NE. 16	5	4	Producers Oil Co. M. J. Wall	571	435	136
NW. NE. 18	5	4	Donk Bros. Coal & Coke	550	399	151
SW. SW. 19	5	4	Donk Bros. Coal & Coke	539	304	235
SE. SE. 23	5	4	Donk Bros. Coal & Coke, J. V. Paine	511	386	125
NW. SE. 28	5	4	Producers Oil Co. Johnson No. 1	499	370	129
N.W.cor.30	5	4	Ohio Oil Co. Niedheimer No. 1	548	325	223
NW. NE. 32	5	4	D. T. Finley Phillip Gloss No. 1	527	380	147
SE.NE.NE.5	5	3	Peabody Coal Co. Donnell	558	471	87
NE. SW. 20	5	3	Sullivan Machinery Co.	493	402	91
SW. SW. 29	5	3	Sullivan Machinery Co.	528	437	91
SE. SW. 3	4	4	D. M. Bissonette	490	380	110

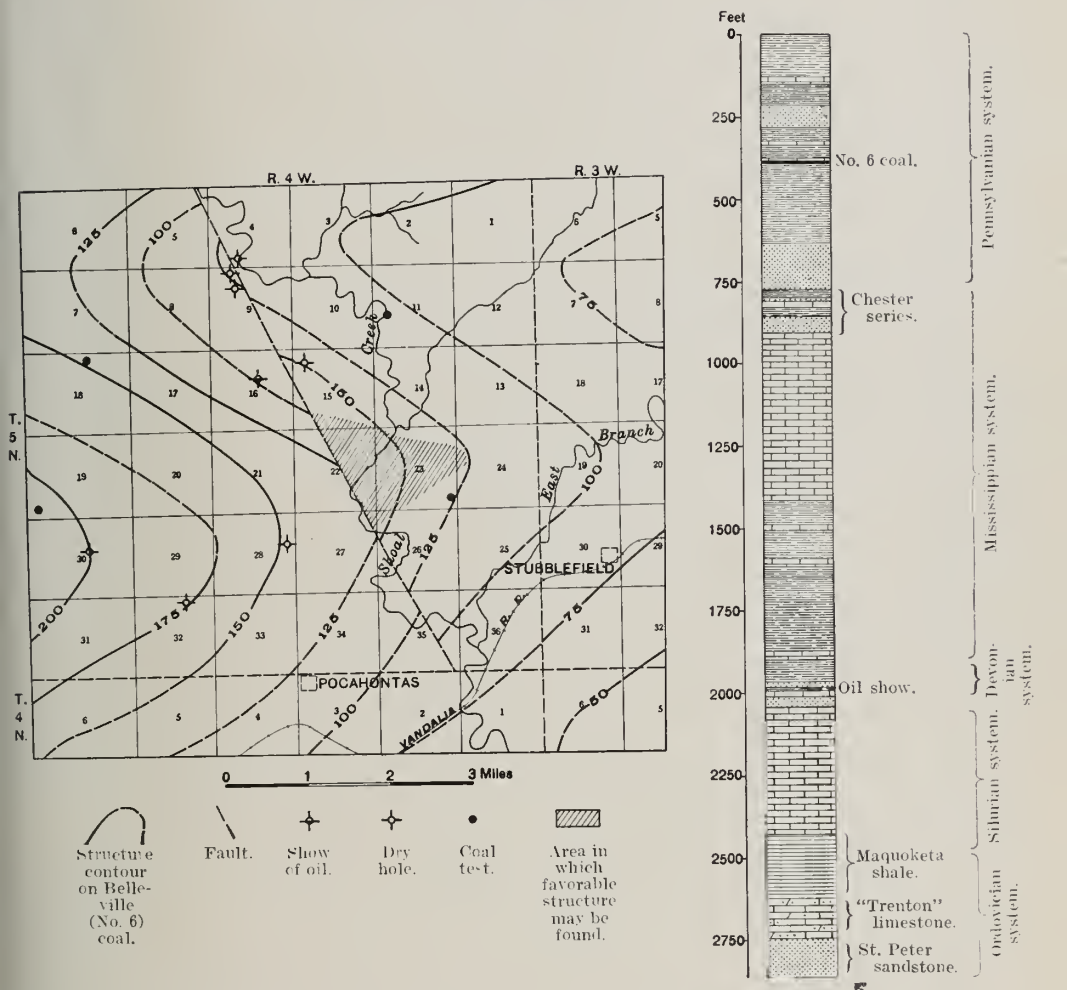

FIG. 7. Structure map and generalized columnar section of area near Stubblefield in Bond County.

The key horizon which is best suited for use in Bond County is a coal which will be found at a depth ranging from 375 to 400 feet. Logs of these tests should be carefully kept for the entire depth of the well, because correlation is difficult in this area and is likely to be faulty with incomplete records.

Several deep wells have been drilled both near Old Ripley and northwest of Pocahontas. None of them appears to have been located on the most favorable part of the structure, although some of them are reported to have had showings of oil.

Although it is to be expected that 8 possible producing horizons will be found in the Bond County area, some of them may be too deep

for consideration at the present time. In the Sam Brown well No. 2 in the SE. ¼ NE. ¼ NW. ¼ sec. 9, T. 5 N., R. 4 W., sands were found at the following depths: 645 to 730, 750 to 760, 830 to 905, 1990 to 2003, and 2025 to 2034 feet.[9] The interpretation of this log is that the formations from 1870 to 1990 feet are basal Mississippian and possibly Devonian, and that the sand at 1990 is Devonian or Silurian. According to this correlation, the basal Silurian and the Trenton have not been drilled in this vicinity. These relations are shown in the columnar section in figure 7.

In the area recommended for testing, these same sands should be found, but at lesser depths because of the higher structure. If favorable structural conditions obtain, it is probable that oil will be found. A deep test should reach the Trenton at about 2500 feet.

MONTGOMERY COUNTY

NOKOMIS AND OHLMAN DOMES

As a result of an investigation of coal data from Montgomery County, two anticlinal folds have been mapped in the vicinity of Nokomis and Ohlman (fig. 8). According to the information available, the larger of these folds is near Ohlman. Further tests are needed to give more detailed information about the structure before a deep test is drilled for oil.

In order to determine the most favorable location for a test on the dome near Ohlman, it will probably be necessary to drill about five structure tests to the coal at about 650 feet, although there is some possibility that the limestone found at shallower depths might prove to be a satisfactory key bed. The tests should be located on the north, northeast, east, southeast, and west borders of the shaded area in figure 8.

A smaller number of tests would determine the conditions in the dome near Nokomis. With the data now available, probably three tests drilled on the north, northwest, and west sides of the shaded area would definitely outline the dome. Although the doming here does not appear to cover as large an area as that near Nokomis, the fact that a smaller amount of preliminary testing is required, and that the folding seems to be somewhat steeper, suggests that the Nokomis dome should be tested before the Ohlman dome.

There is probably no chance to get production at depths less than 700 feet on either dome, as many wells have already been drilled through the strata to that depth without getting a trace of oil. The Pennsylvanian strata will probably be found to continue to a depth of about 1250 feet. In case a favorable structure is found, a test should be carried to a depth of about 1600 feet in order to test the Chester of the upper Mississippian. The possible oil sands are shown in the columnar section (fig. 8).

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[9] Mylius, L. A., Revised correlations, Oil and gas in Bond, Macoupin and Montgomery counties by R. S. Blatchley: Ill. State Geol. Survey Bull. 28, p. 18, Oct. 1923.

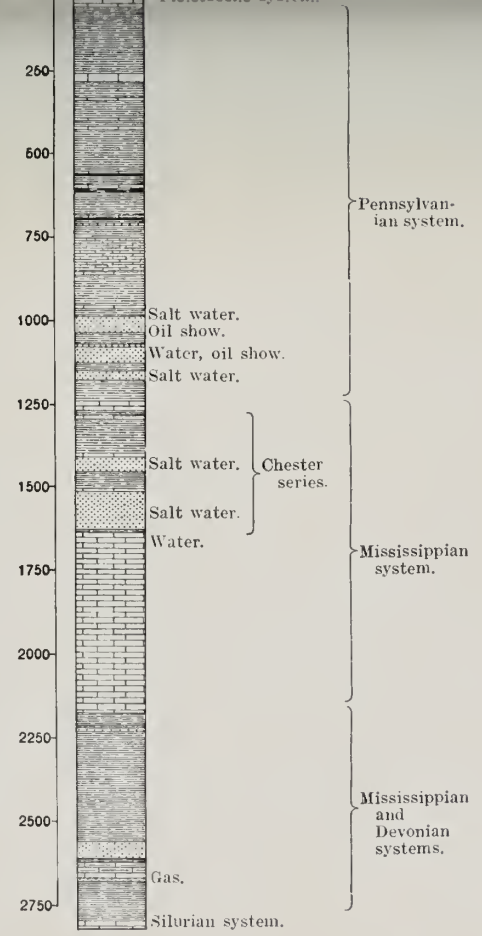

FIG. 8. Structure map and generalized columnar section of area in the vicinity of Ohlman and Nokomis in Montgomery County.

At the present time the Ohlman Dome Oil and Gas Company of Nokomis is drilling a well four miles north of Nokomis which should give some additional information on the stratigraphy and structure of the region.

Favorable Areas in Southern Illinois

In the present report only one locality in the southern part of the State is considered. After the completion of certain detailed work, now planned or under way, other areas in this general part of the State will be described.

St. Clair and Washington Counties

The Darmstadt Area

The Darmstadt area is located in southeastern St. Clair and southwestern Washington counties. It has been described previously,[10] but a new map was made for the present paper with a contour interval of 25 instead of 50 feet. A greater amount of detailed structural information can be shown as a result of this change.

Near Darmstadt there is an area which should be investigated further. Data on the elevation of coal beds found in the neighborhood have been interpreted as indicating the presence of a plunging anticline and the area worthy of further consideration is shaded in figure 9. Test wells should be drilled along the middle part of the shaded area to determine whether the anticline plunges continuously, or is separated into local domes by alternations of steep plunges and reverse dips. If such domes are found along this anticline, deep tests should be drilled to test the oil possibilities.

Structure tests should be drilled to the coal at depths varying from 150 to 200 feet. Probably 3 or 4 such tests would give the information needed to decide the advisability of putting down a deep test.

The Darmstadt area is of particular interest because beds within easy reach of the drill are known to contain at least small amounts of oil nearby. In the vicinity of Sparta, and about 15 miles south of Darmstadt, several nice wells were found in the Chester beds. Six miles south of Darmstadt, near Marissa, two of the deep wells reported showings of oil or gas. As Marissa is on the same general fold as that at Darmstadt, and as shows of oil were found on parts of the structure which do not appear to be particularly favorable, the chances of finding oil on any dome which might be found in the area are considered good.

At least four sand horizons lie within easy reach of the drill in the vicinity of Darmstadt. Near Marissa, they have been reported at the following depths: 660 to 670, 685 to 697, 777 to 786, 789 to 800, and 822 to 842 feet. Sands will probably be found at these same horizons in the Darm-

[10] Shaw, E. W., U. S. Geol. Survey Geol. Atlas, New Athens-Okawville folio (No. 213), 1921.

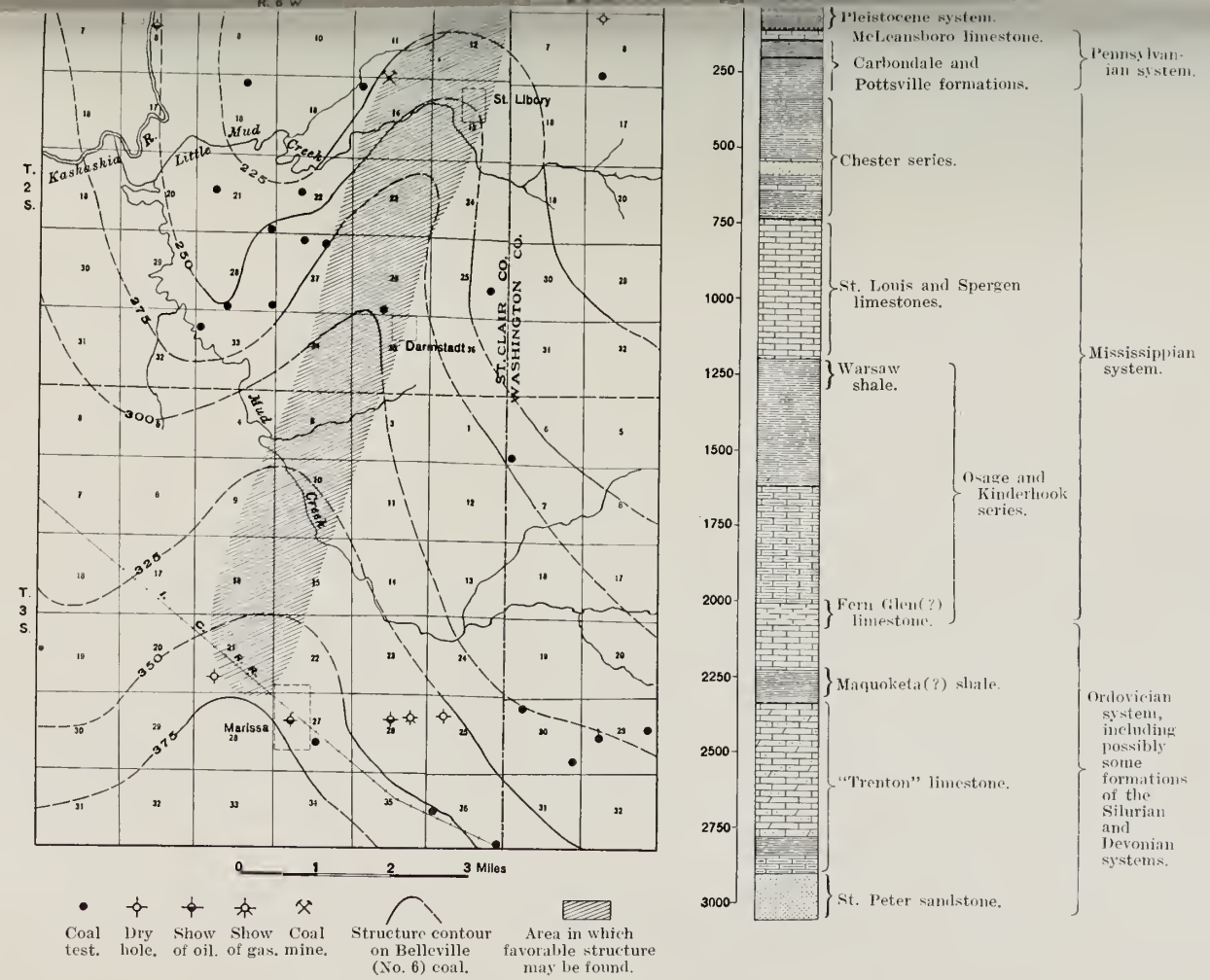

FIG. 9. Structure map and generalized columnar section of Darmstadt area in St. Clair and Washington counties.

stadt area. If favorable structural conditions are found, an oil test should be drilled to 800 feet or more to test the upper part of the Mississippian at least. The character of the rocks underlying the area is shown in the columnar section, figure 9.

GENERAL SUMMARY

Indiscriminate deep drilling in advance of determination of structure is, in most cases, much more expensive and much less conclusive than the structure drilling program outlined. Therefore, a systematic program of determining structure in advance of deep drilling has been suggested, and certain areas in which such drilling can well be undertaken have been described. It is desirable that Illinois operators generally will recognize the value of test drilling, and will use it. In view of the fact that one half of the dry holes drilled in Illinois during 1924 were drilled on locations which were obviously unpromising from a geological point of view, operators will probably be able to reduce the percentage of failures by locating their tests on favorable structures. If proper testing is carried out, it is believed that one or more new oil pools will be discovered, and that new drilling will show more profit than in the past year.

Additional help can be obtained from the State Geological Survey in the matter of identification of key beds and deeper beds which might contain oil. This service can be most useful to the operator if cutting samples are carefully kept, and sent to the Survey. Where possible, the Survey will also provide assistance in determining the elevation of structure tests. As valuable information not included in the present report can be obtained, operators are advised to address any inquiries they may have to the Illinois State Geological Survey, Urbana, Illinois.